heterogeneous tumors. The insert has an outer low-uptake volume encompassing a high-uptake inner volume. SUV ratio of 1:2 was intended. The second phantom accommodates applicators that can hold Farmer ion chamber in a location matching the center of the inner volume and in four locations matching the outer volume. 4D PET/CT scans of the phantom were acquired with three breathing wave forms of ideal sinusoid and two patient-specific breathing patterns fed to the moving platform. Patient-specific wavefronts were selected to represent a regular and an irregular breather. Two scenarios were investigated for image reconstruction, planning and delivery: a gate 30-70 window, and no gating. ITVs were delineated on the obtained 4D PET/CT scans and 21 VMAT-SIB treatment plans were generated with two fractionation regimens:

· Conventional fractionation: 2 Gy/fx to outer ITV, 2.4Gy/fx to high SUV inner ITV, 30 fx.

· Hypo-fractionation delivered in both flattening filter and flattening filter free (FFF) modes: 8 Gy/fx to outer ITV, 9 Gy/fx to inner ITV,5 fx. Treatment plans were delivered in two gating scenarios: no gating and gate 30-70. Two ion chamber readings for the inner ITV, and two readings for one arbitrarily selected outer ITV were acquired. Measured doses in the inner ITV and the outer ITV were compared to planned doses.

Results: For both fractionation regimens and both delivery modes, measured doses in outer and inner ITV were between 93 and 99% of planned doses. Measured dose as compared to planned dose demonstrated independence from breathing pattern or gating window. In particular, measured doses in FFF mode were consistent with measured doses in filtered beam mode, 94-96% of planned dose.

Conclusion: The phantom has been validated for end-to-end use from 4D PET/CT scanning and radiotherapy planning, to dosimetric verification. Measured doses for SIB plans were in reasonable agreement for all three breathing patterns and for both gating windows and delivery modes.

Electronic Poster: Physics track: Inter-fraction motion management (excl. adaptive radiotherapy)

EP-1775

CBCT based prostate IGRT accuracy and PTV margins

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Purpose or Objective: *Purpose*: Image guided radiotherapy (IGRT) is the standard treatment of prostate cancer, widely based on Cone Beam CT (CBCT). The accuracy of CBCT based prostate registration is however not well established, conditioning the choice of the Planning Target Volume (PTV) margins. The goal of the study was to quantify the uncertainty of this registration and propose therefore appropriate margins.

Material and Methods: *Materials and methods*: A total of 306 prostate CT to CBCT alignments were analyzed in 28 prostate cancer patients treated by IGRT. The prostate was manually delineated on all the CBCT. Three prostate alignment modalities were afterwards simulated and compared, based on skin marks, on CBCT registration performed by the technologist at the fraction (IGRTt) and on the prostate contours. The IGRT uncertainty (IU) was defined as the difference between the contour based and the CBCT alignments, in each space direction. Dice index (DI) were calculated. Margins were calculated, based on the IU and the Van Herk formula.

Results: *Results*: The mean (min;max) absolute values of the IU were, in mm: 1.5 (0;10), 0.7 (0;12) and 0.9 (0;7), in antero-posterior (A/P), cranio-spinal (CS) and lateral directions, respectively. After IGRTt alignment, 25 prostate (11% of cases) still projected partially out of the PTV, corresponding to an average prostate volume (min; max) of 2.3 cc (0.0;12.6). The mean + standard deviation of the DI were 0.84 + 0.08, 0.90 + 0.07 and 0.93 + 0.03 for the skin marks, CBCTt and contours registration, respectively. For at least 95% of the IGRT registrations covering 100% of the prostate, the required A/P, CS and lateral PTV margins (mm) should be at least 4.5, 2.0 and 3.0, respectively. The Van Herk PTV margins (mm) were 5.5, 4.1 and 3.0 in the A/P, CS and lateral directions, respectively.

Conclusion: *Conclusions:* CBCT based prostate registration presents uncertainties requiring at least 3 to 5 mm PTV margins.

EP-1776

Assessment of setup uncertainties in modulated treatments for various tumour sites

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Purpose or Objective: The aim of this study was to analise the patients setup errors for various tumor sites based on clinical data from modulated treatments using cone beam computed tomography (CBCT) imagine guidance and portal imaging for breast site. It was also calculated the planning target volume (PTV) margins of all disease sites and stipulated action level for online correction.

Material and Methods: The patients analyzed in this study were treated in our institution between January 2012 and December 2014 with VMAT and IMRT via flash technique for breast cancer. The various tumor sites were divides into six categories; 175 breast (1173 fractions); 53 thorax (475 fractions); 60 prostate (585 fractions); 100 H&N (858 fractions); 100 SNC (789 fractions) and 77 pelvis (620 fractions).

For every treatment fraction, it were acquired KV-CBCT images using the on-board imager (OBI) (Varian Medical Systems), and for breast cancer it were acquired MV portal images using the Electronic Portal Imaging Device (EPID) (Siemens AG) in the first week and twice per week. The registration procedure was performed for all treatments sites according to the tumor localization. For prostate site, it was also analyzed the physiological state of bladder and rectum.

It were calculated the systematic (Σ) and random (σ) errors of couch shift obtained, and PTV margin ($2{,}5\Sigma + 0{,}7\sigma$).

Results: The Σ and σ for all treatment sites are summarized in table 1 as well PTV margins.

Table 1. The systematic and random errors and PTV margins

	Systematic Error (Σ)			Random Error (σ)		
	Lateral (mm)	Longitudinal (mm)	Vertical (mm)	Lateral (mm)	Longitudinal (mm)	Vertical (mm)
Breast	1.67	1.30	1.57	1.87	1.43	1.85
Thorax	2.15	2.45	1.66	3.33	3.84	3.44
Prostate	2.30	1.32	2.00	2.71	1.78	2.73
Prostate operated	1.94	1.39	1.97	2.89	2.31	2.66
H&N	1.22	1.18	1.25	1.94	1.94	2.07
SNC	1.00	1.27	0.85	1.47	1.56	1.19
Pelvis	1.71	2.16	2.28	3.75	2.72	3.65
	PTV margins					
	Lateral (mm)		Longitudinal (mm)		Vertical (mm)	
Breast	5.47		4.25		5.22	
Thorax	7.70		8.82		6.56	
Prostate	7.66		4.54		6.90	
Prostate operated	6.87		5.10		6.79	
H&N	4.40		4.32		4.57	
SNC	3.52		4.28		2.95	
Pelvis	6.91		7.29		8.25	

The largest magnitude of Σ and σ for H&N was 1.94 mm, SNC was 1.56 mm, breast was 1.87 mm, thorax was 3.33 mm, pelvis was 3.75 mm and prostate was 2.89 mm. The PTV margins required are <4.5 mm for brain and H&N lesions, <5.5 mm for breast cancers, but range from 4.5 to 9 mm for thorax, prostate and pelvis lesions.
Theses values indicate the setup variations of each patient. The variations were smaller for the breast, SNC and H&N cohorts than the prostate, pelvis and thorax cohorts. The pelvis and breast cohorts showed the greatest variation in lateral direction and the prostate cohorts in vertical direction. The largest variation were presented in thorax cohorts in longitudinal direction and the lowest were in the SNC cohorts.

Conclusion: As the setup errors vary according to each immobilization systems, the analysis of each institution`s specific setup errors is essential for determining the PTV margins. The results were also used to define action level for online correction.

EP-1777

MRT investigation of prostate and lymph nodes movements: implications on planning target volume?

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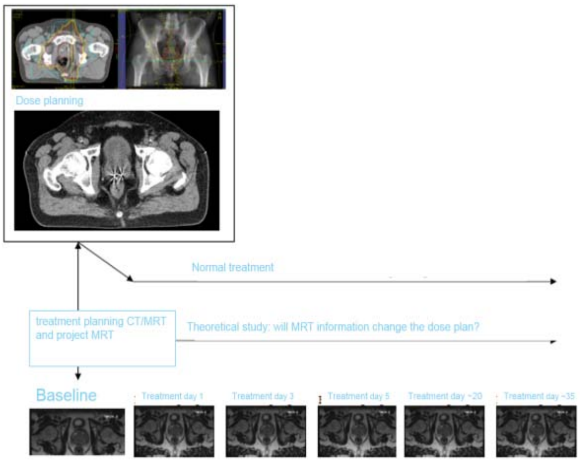
Purpose or Objective: The purpose of this project is to gather knowledge on the movement of pelvic lymph nodes relative to the prostate, seminal vesicles and bones in the pelvis and how this may affect the patient treatment plan.

Material and Methods: Until present, 10 patients have been included in the study. All patients have diagnosed prostate cancer and were treated with radiation therapy with curative intent. The patients followed the normal preparation and treatment procedure at our clinic - however, six additional MRI scans were acquired (baseline: before RT, on treatment day 1, 3, 5, 20 and 35) see figure. In each image set, several structures were delineated including fiducial markers, bony structures and lymph nodes. A radiologist identified lymph nodes along the common spread paths of prostate cancer. No suspected pathological nodes were found. Oncentra (Elekta) was used for image registration. Baseline images were defined as reference images and all other examinations were registered to the reference in two separate ways; bone matching and fiducial markers matching. For the bone matching, four structures were outlined; the disc between S1-S2, head of the right and left femur and the pubic symphysis. For the fiducial marker matching, the three gold markers in the prostate were outlined. In both cases the images were manually matched. Lymph node, seminal vesicle and prostate movements and morphological change were evaluated In MATLAB. Lymph nodes were grouped into regions: para-aortic (PA), common iliac (CI), pre-sacral (PS), internal iliac (II), obturator (Obt), and external iliac (EI) lymph nodes.



Results: We found that prostate moves up to 10 mm in anterior-posterior direction and up to 5 mm in right-left and cranio-caudal directions relative to bony anatomy from baseline scan. The lymph node group with the largest movements in right-left direction were CI with up to 20 mm difference from baseline. In the anterior-posterior and cranio-caudal directions, the maximum movement was 9 mm relative to bone from baseline scan. For the lymph nodes in the EI and PS regions, a significant difference was found depending on whether bone or fiducial markers were used for registration in right-left or cranio-caudal directions. In the other cases, no statistically significant difference between bone matching and fiducial marker matching was found

Conclusion: Preliminary findings suggest that the pelvic lymph nodes are more mobile than expected, indicating the need to account for that in treatment planning. However, more patients need to be included in the study before a conclusion can be drawn on the implications on the treatment plan.

EP-1778

On the feasibility of performing a 3D-scan with your own smartphone

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Purpose or Objective: Optical 3D Surface Scanner (3D-OSS) is a simple and easily reproducible method for patient alignment, and is an accurate tool to show anatomical changes, for example, in breast locations. The aim of this study was to evaluate the feasibility of both achieving within a few minutes an 3D-OSS using a smartphone and creating an image fusion between this 3D-OSS and the CT scanner, in a simple, cheap and reliable way.

Material and Methods: A smartphone and a free commercial app (TRNIO, www.trnio.com) were used to create an 3D-OSS. This app takes a series of pictures of your object as you move your smartphone around it. After a scan is completed, a 3D model will be generated on your phone. This 3D map is available for downloading on the TRNIO website. Although there are several image reconstructing algorithms available, in order to first show the feasibility of the method described here we will be using the commercial app. In the meantime,